Useful Relationships

$$E_{in} - E_{out} = \Delta E_{system}$$

$$\dot{E}_{in} - \dot{E}_{out} = \frac{d}{dt} E_{system}$$

$$m_{in} - m_{out} = \Delta m_{system}$$

$$\dot{m}_{in} - \dot{m}_{out} = \frac{d}{dt} m_{system}$$

$$\dot{m} = \rho \vec{V} A$$

$$w_{b,out} = \int P \, dv$$

$$x \equiv \frac{m_g}{m}$$

$$x = \frac{v - v_f}{v_g - v_f} = \frac{u - u_f}{u_g - u_f} = \frac{h - h_f}{h_g - h_f} = \frac{s - s_f}{s_g - s_f}$$

$$h = u + Pv$$

$$h \approx h_{f@T} + v_{f@T}\left(P - P_{sat@T}\right)$$

$$\Delta P = \rho g \Delta z$$

$$\eta_{th} \equiv \frac{\text{desired output}}{\text{required input}}$$

$$\text{COP} \equiv \frac{\text{desired output}}{\text{required input}}$$

$$\left(\frac{Q_L}{Q_H}\right)_{\text{rev}} = \frac{T_L}{T_H}$$

$$PV = mRT = N\overline{R}T$$

$$\overline{\text{R}} = \begin{cases} 8.314 \ \frac{\text{kJ}}{\text{kmol} \cdot \text{K}} \\ 1545 \ \frac{\text{ft} \cdot \text{lbf}}{\text{lbmol} \cdot \text{°R}} \\ 1.986 \ \frac{\text{BTU}}{\text{lbmol} \cdot \text{°R}} \end{cases}$$

$$F = ma$$

$$1 \text{ N} = (1 \text{ kg})\left(1 \text{ m/s}^2\right)$$

$$1 \text{ lbf} = (1 \text{ lbm})\,(1 \text{ g})$$

$$1 \text{ lbf} = (1 \text{ lbm})\left(32.174 \text{ ft/s}^2\right)$$

$$1 \text{ lbf} = (1 \text{ slug})\left(1 \text{ ft/s}^2\right)$$

Useful Conversions

Mass and Density
1 kg = 2.2046 lb
1 g/cm^3 = 10^3 kg/m^3
1 g/cm^3 = 62.428 lb/ft^3
1 lb = 0.4536 kg
1 lb/ft^3 = 0.016018 g/cm^3
1 lb/ft^3 = 16.018 kg/m^3

Length
1 cm = 0.3937 in
1 m = 3.2808 ft
1 in = 2.54 cm
1 ft = 0.3048 m

Velocity
1 km/h = 0.62137 mile/h
1 mile/h = 1.6093 km/h

Volume
1 cm^3 = 0.061024 in^3
1 m^3 = 35.315 ft^3
1 m^3 = 1000 liters
1 L = 10^{-3} m^3
1 L = 0.0353 ft^3
1 in^3 = 16.387 cm^3
1 ft^3 = 0.028317 m^3
1 gal = 0.13368 ft^3
1 gal = 3.7854 × 10^{-3} m^3

Force
1 N = 1 kg·m/s^2
1 N = 0.22481 lbf
1 lbf = 32.174 lb·ft/s^2
1 lbf = 4.4482 N

Pressure
1 Pa = 1 N/m^2
1 bar = 10^5 N/m^2
1 bar = 100 kPa
1 Pa = 1.4504 × 10^{-4} lbf/in^2
1 atm = 1.01325 bar
1 atm = 14.696 lbf/in^2
1 lbf/in^2 = 6894.8 Pa
1 lbf/in^2 = 144 lbf/ft^2

Energy and Specific Energy
1 kWh = 3.6 MJ
1 J = 1 N·m = 0.73756 ft·lbf
1 kJ = 737.56 ft·lbf
1 kJ = 0.9478 Btu
1 kJ/kg = 0.42992 Btu/lb
1 ft·lbf = 1.35582 J
1 Btu = 778.17 ft·lbf
1 Btu = 1.0551 kJ
1 Btu/lb = 2.326 kJ/kg
1 kcal = 4.1868 kJ

Energy Transfer Rate
1 W = 1 J/s = 3.413 Btu/h
1 kW = 1.341 hp
1 Btu/h = 0.293 W
1 hp = 2545 Btu/h
1 hp = 550 ft·lbf/s
1 hp = 0.7457 kW

Specific Heat
1 kJ/kg·K = 0.238846 Btu/lb·°R
1 kcal/kg·K = 1 Btu/lb·°R
1 Btu/lb·°R = 4.1868 kJ/kg·K

Others
1 ton of refrigeration = 200 Btu/min
1 ton of refrigeration = 211 kJ/min
1 volt = 1 watt/ampere

Standard Acceleration of Gravity
g = 9.80665 m/s^2
g = 32.174 ft/s^2

Standard Atmospheric Pressure
1 atm = 1.01325 bar
1 atm = 14.696 lbf/in^2
1 atm = 760 mmHg = 29.92 inHg

Temperature Relations
T(°R) = 1.8 T(K)
T(°C) = T(K) − 273.15
T(°F) = T(°R) − 459.67